



Intel® Smart Sound Technology Driver

Bring Up Guide

Revision 1.91

August 2021

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Revision History

Document Number	Revision Number	Description	Revision Date
613171	1.0	<ul style="list-style-type: none"> Initial release. 	June 2019
	1.1	<ul style="list-style-type: none"> Updated BIOS Configuration for USB/BT audio enable. Updated Audio DSP Features Check for USB/BT audio offload. Added additional statement for device class code. 	August 2019
	1.2	<ul style="list-style-type: none"> Updated Section 1.2 on Acronyms and Terminology and reference document. Updated picture of SST architecture. Added description into Section 2.3 For Audio Codec Selection and External NHLT settings. Included the BT audio configuration in Chapter 3 NHLT and DMIC Blob Integration. Added description of BT and UAOL driver installation into Section 4.1. Added endpoint descriptor check in Device Manager in Section 5.4 to Section 5.7. 	November 2019
	1.3	<ul style="list-style-type: none"> Added Section 5.8 on Multi-Voice Assistant and Section 2.3 on MVA BIOS configuration. Updated Section 5.6 on USB Audio offload screenshot. Added RVP default NHLT as sample for NHLT generation. 	March 2020
	1.4	<ul style="list-style-type: none"> Updated Section 1.3 with Ref005,006, and 007. Added Section 5.5 on BT® Audio offload GPIO pin configuration. Updated Section 5.6 USB audio offload. 	May 2020
	1.5	<ul style="list-style-type: none"> Added MVA ext inf certified standalone information in Section 5.8. Added suggestion to install GFX before SST driver for TGL 20H1 system in Section 4.1. Removed "Install SST before GFX" from Chapter 7. 	September 2020
	1.6	<ul style="list-style-type: none"> Updated Section 1.3. Added Chapter 6 for -26dBFS MIC sensitivity calibration. 	December 2020
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	1.8	<ul style="list-style-type: none"> Updated Section 2.3 for Audio DSP NHLT Endpoints Configuration for ADL. Updated Chapter 3 for IADK 2.7.0. 	April 2021
	1.9	<ul style="list-style-type: none"> Updated Section 2.3 and Section 3.4 for Audio DSP NHLT Endpoints Configuration for ADL. Added ADL_NHLT.zip in attachment. 	May 2021



Document Number	Revision Number	Description	Revision Date
	1.91	<ul style="list-style-type: none">• Updated Section 2.3 for BT A2DP Offload and UAOL Config in BIOS for ADL• Updated Section 5.5 on BT A2DP offload	August 2021

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1 Introduction

1.1 Purpose and Scope of Document

This document provides installation instructions and general usage guidance for Intel® Smart Sound Technology (Intel® SST) Driver (formerly Audio DSP Driver).

The Intel® Smart Sound Technology Driver supports Alder Lake (ADL), Coffee Lake (CFL), Cannon Lake (CNL), Comet Lake (CML), Ice Lake (ICL), Jasper Lake (JSL), Rocket Lake (RKL), Tiger Lake (TGL) and Whiskey Lake (WHL) platforms with Intel audio DSP integrated on Windows* 10/11 64-bit Operating Systems.

1.2 Acronyms and Terminology

Term	Description
ADL	Alder Lake
ACPI	Advanced Configuration and Power Interface
BIOS	Basic Input/Output System
BKC	Best Known Configuration
BT	Bluetooth®
CFL	Coffee Lake
CML	Comet Lake
CNL	Cannon Lake
CS	Connected-Standby (Instant Go)
CRB	Customer Reference Board
DMIC	Digital Microphone
DSP	Digital Signal Processing
EVAD	External Voice Activity Detection
FW	Firmware
Gfx	Graphics
HDA or HD-Audio	High Definition Audio
I2S	Inter-IC Sound, A data interface

Term	Description
ICL	Ice Lake
IHV	Independent Hardware Vendor
Intel® OED or OED	Intel® Offload Engine Driver
Intel® SST	Intel® Smart Sound Technology
Intel® WOV	Intel® Wake on Voice. (Old name: LPAL, Low Power Always Listening)
ISV	Independent Software Vendor
JSL	Jasper Lake
LP	Low Power
MCP	Multi-Chip Package
MSFT	Microsoft* Corporation
NHLT	Non-HD-Audio Link Table
Non-CS	Non-Connected-Standby (Non-Instant Go)
OS	Operating System
PCH	Platform Controller Hub
RKL	Rocket Lake
RVP	Reference Validation Platform
SDW/SNDW	SoundWire*
SUT	System Under Test
TBD	To be determined
TGL	Tiger Lake
UAA	Universal Audio Architecture
UAOL	USB Audio Offload
ULT	Ultra-Thin
VAD	Voice Activity Detection
WHL	Whiskey Lake

1.3 Related Documents and References

ID	Document Number	Document Title
Ref001	613651	Intel® Smart Sound Technology Validation and Debug Guide
Ref002	610730	Intel® Wireless Technical Advisory: Bluetooth® Audio Offload
Ref003	642222	Intel® Smart Sound Technology FW Key Usage on Non-Production Driver Sighting Alert
Ref004	microphone-array-geometry-descriptor-format	Microphone Array Geometry Descriptor Format
Ref005	620882	Intel® Smart Sound Technology ISV/IHV Enabling Tutorial User Guide
Ref006	620544	Intel® Smart Sound Technology Multi-Voice Assistant (MVA) Enabling Dashboard
Ref007	571948	Audio, Voice, and Speech System Implementation Design Guide
Ref008	595819	Intel® Speech Platform Evaluation Toolset Test Guide
Ref009	598645	Intel® Smart Sound Technology (Intel® SST) Customer Enabling Update Technical Advisory
Ref010	630235	Intel® Smart Sound Technology Acoustic Context Awareness Bring Up Guide
Ref011	632541	Intel® Smart Sound Technology Audio Firmware Signing and Manifesting User Guide
Ref012	634270	Intel® Smart Sound Technical Advisory: USB Audio Offload
Ref013	631659	USB Audio Offload (UAOL) Disable
Ref014	633107	Audio Processing Object (APO) Support on Bluetooth® and USB Offload Endpoints Technical White Paper
Ref015	633975	Intel® Smart Sound Technology – Audio Processing on USB and Bluetooth® Offload Endpoint Guidance
Ref016	632502	Intel® Wake on Voice (Intel® WoV) – Customer Data Requirement Specification
Ref017	576591	Intel® TGL-LP Platform Controller Hub External Design Specification
Ref018	619362	Intel® ADL-S Platform Controller Hub External Design Specification
Ref019	639169	Alder Lake BIOS NHLT Binary Integration Flow User Guide
Ref020	645276	Intel® GNA Introduction
Ref021	645278	ADL Athena - Intel® GNA Validation and MOS Test
Ref022	638665	Project Athena Audio Process Technical Training Material
Ref023	631623	Athena System Design Specification - Alder Lake Platform

§§

2 Platform Details

2.1 Audio Subsystem Overview

Intel® Smart Sound Technology (Intel® SST) supports HD-Audio codecs connected to designs based on Tiger Lake (TGL), Cannon Lake (CNL), Coffee Lake (CFL), Comet Lake (CML), Ice Lake (ICL), and Whiskey Lake (WHL) Platform. Intel® SST is supported both on Connected Standby and Non-Connected Standby platforms. The Audio DSP in the HD-Audio controller controls both the HD-Audio codec and the audio on the Display Port and HDMI interfaces. This HD-Audio link for the audio codec supports multiple voltages (1.5 V/1.8 V/3.3 V).

Audio DSP in the HD-Audio controller meets the Microsoft* UAA compliancy. With DSP integrated into the PCH, the offloaded audio goes through multi-layer audio processing inside the DSP with the Intel® SST FW loaded.

Note: Be aware of all Intel® SST features available on Standard (non-InstantGo*) platforms. Intel® WOV saves power while in S0 — but currently cannot wake a system while in S3 on the Standard (non-Instant Go*) platforms.

Figure 2-1. Audio System

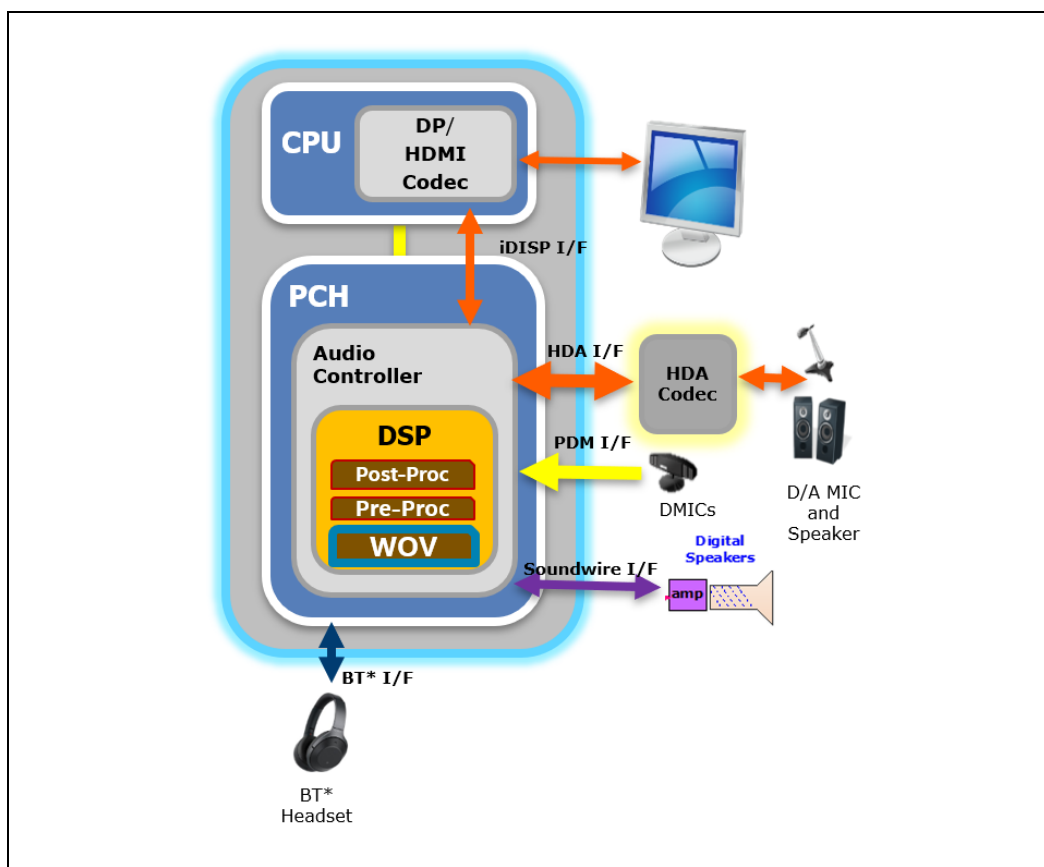


Figure 2-2. SoundWire*-Based Smart AMP

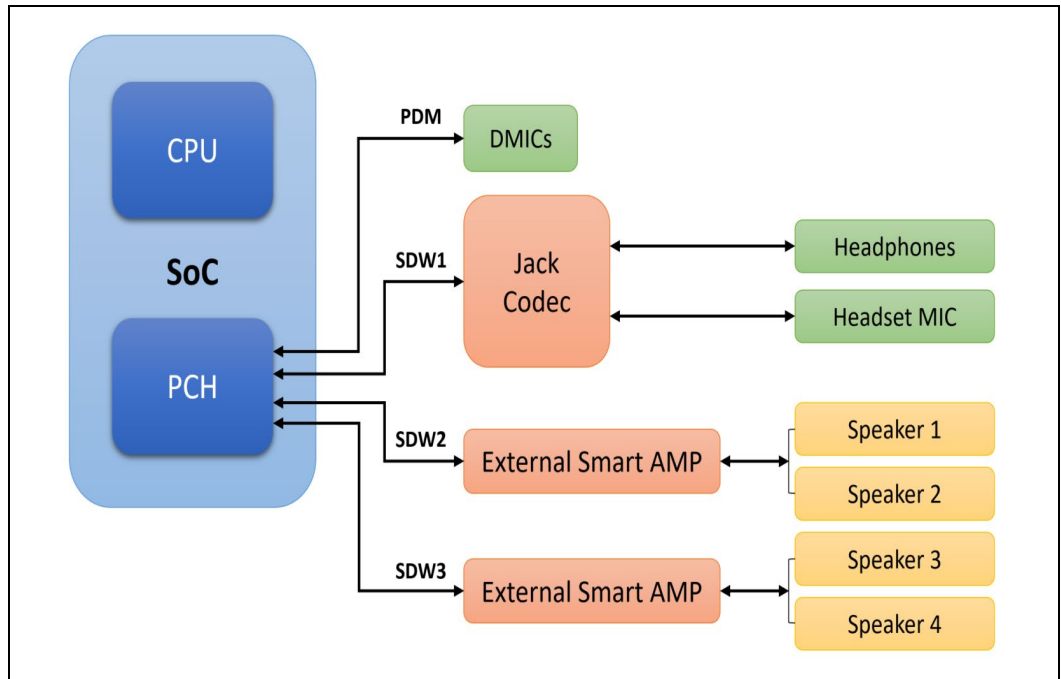
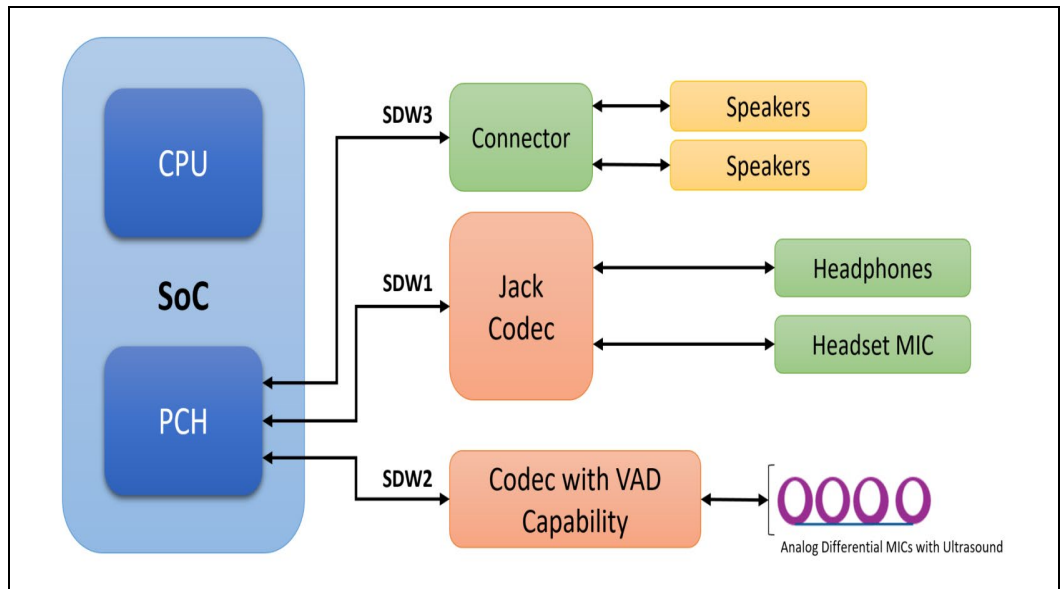


Figure 2-3. Intel® WOV with SoundWire*-Based External VAD



2.2 System Configuration

Platform	Alder Lake, Cannon Lake, Coffee Lake, Comet Lake, Ice Lake, Jasper Lake, Rocket Lake, Tiger Lake, Whiskey Lake
Operating System	Windows* 10 x64 RS5/RS6/20H1/20H2 and Window* 11 x64
BIOS	Audio DSP enabled, HDA codec enabled, SoundWire* enabled, BT/USB audio enabled

Intel® SST driver should be installed on systems with at least 1 GB of system memory. There should be enough hard disk space in the directory on the system in order to install this software.

Note: Contact the respective BIOS AE for BIOS specifications.

2.3 Mandatory BIOS Configuration for Intel® SST

Enter BIOS by tapping F2 once the platform starts to boot.

For SST Enable:

[Intel Advanced Menu/PCH-IO Configuration/HD Audio Configuration](#)

HD Audio = <Enabled>
Audio DSP = <Enabled>

Audio DSP Compliance Mode:

If DMIC is connected to PCH, select <Non-UAA (Intel® SST)>

If DMIC is connect to codec, select <UAA (HDA Inbox/Intel® SST)>

For Audio Codec Selection:

[Intel Advanced Menu/PCH-IO Configuration/HD Audio Configuration](#)

HDA-Link Codec Select: Selecting "Platform Onboard" means that a single verb table is installed. On the other hand, selecting "External Codec" will use multiple verb tables. Depending on environment, select <Platform OnBoard> or <External Codec Kit>

For Audio Link Selection:

[Intel Advanced Menu/PCH-IO Configuration/HD Audio Configuration](#)

- **If it uses HDA - Audio Link Mode** choose <HD Audio Link>
- **If it uses I2S - Audio Link Mode** choose <I2S>
- **If it uses SoundWire***
 - For default SoundWire setting - **Audio Link Mode** choose <SoundWire>
 - For different SoundWire setting - **Audio Link Mode** choose <Advanced Link Config> and set:
 - HDA Link []
 - DMIC #0 [X]
 - DMIC #1 [X]

- SSP #0 []
- SSP #1 []
- SSP #1 []
- SSP #2 []
- SSP #3 []
- SSP #4 []
- SSP #5 []
- SNDW #1 [X]
- SNDW #2 [X]
- SNDW #3 []
- SNDW #4 []
- [X] – Enabled [] – Disabled

NOTES:

1. Enable or disable the required audio link from the menu above.
2. Enable the Audio Link in RVP by following the respective rework instructions.

For Post-Processing Selection:

[Intel Advanced Menu/PCH-IO Configuration/HD Audio Configuration/HD Audio DSP Features Configuration](#)

Audio DSP Pre/Post-Processing Module Support: Select corresponding post-processing effect in options.

If there is Custom Module to add, select Custom Module 'Alpha'/'Beta'/'Gamma' and input corresponding GUID of the IP. Also, corresponding GUID mapping needs to be added in Platform ACPI code.

Intel® Wake on Voice (Intel® WoV) Support for Personal Assistant (PA):

Intel® Wake on Voice (WoV) is running from Intel DSP, it could wake system up from Modern Standby (S0ix) or Ready Mode (S0 screen off). When system enters S0, Intel® WoV triggers personal assistant (PA).

Intel® WoV solution provides integrated solution that provides personalization and convenience. Intel® WoV running on DSP supports Microsoft* Windows* 10 RS5/RS6 Cortana* and Amazon* Alexa* as Hardware Keyword Spotter for keyword detection. Intel® WoV supports two PAs simultaneously running on the system configuration. PA selection could be Microsoft* Windows* 10 RS5/RS6/20H1/20H2 Cortana*, Amazon* Alexa*, or any new PA integrated with Intel® WoV.

Intel® Wake on Voice on DSP Support for 20H1 OS MVA:

To configure Intel® Wake on Voice support for MVA, the following setup is needed:

[Intel Advanced Menu/PCH-IO Configuration/HD Audio Configuration/HD Audio DSP Features Configuration](#)

WoV (BIT 0) = <TRUE>

VAD API Mode (BIT 8) = <Windows 10 Voice Activation>

Note: Refer to [Section 5.8](#) for the remaining configuration for MVA.

NOTES:

1. For Modern Standby system, BIOS needs to add PEP constraint code to support Audio Controller being in D0:F1 state.

```
Package() {"\\_SB.PCI0.HDAS",0x1, Package() {0, Package() {0xFF,
0, 0x81}}},// 15 -cAVS(HDAudio)
```

2. Post-processing modules can be enabled together with Intel® WoV.
3. More than one post-processing modules can be enabled depending on the resources used by ISV. For Post-processing modules combinations, contact the ISV for more information.

CS/Non-CS Settings:

Intel Advanced Menu/ACPI SETTINGS

Low Power S0 Idle Capability

- a. If CS is supported, select <ENABLED>
- b. If CS is not supported, select <DISABLED>

RTD3 Settings:

Intel Advanced Menu/ACPI D3Cold Settings

ACPI D3Cold Support = <Enabled>

BT® Audio Offload Settings: (For ICL, CML v2, TGL and ADL):

Intel Advanced Menu/CNVi Configuration / ®Audio Offload

BT® audio offload mode support = <Enabled>

Intel Advanced Menu/PCH-IO Configuration/HD Audio Configuration/HD Audio DSP Features Configuration/Audio DSP NHLT Endpoints Configuration/Bluetooth®

BT® audio offload mode support = <Enabled>

Intel Advanced Menu/PCH-IO Configuration/HD Audio Configuration/HD Audio DSP Features Configuration/Audio DSP Feature Support

Bluetooth® Sideband [X]

BT® Intel HFP [X]

BT® Intel A2DP [X] (For TGL-R and ADL only)

USB Audio Offload Settings: (For ADL):

Intel Advanced Menu/PCH-IO Configuration/USB Configuration

USB Audio Offload [X]

External NHLT Settings: (For ICL, CML v2 and TGL only):

[Intel Advanced Menu/PCH-IO Configuration/HD Audio Configuration/HD Audio DSP Features Configuration/Audio DSP NHLT Endpoints Configuration/NHLT External Table](#)

This is an optional setting that depends on which NHLT settings you would use for CML v2/ICL/TGL platforms:

1. Load the customized NHLT which is imported to BIOS by customer, enable < NHLT External Table>
2. Load default DMIC blob integrated in RVP, disable < NHLT External Table>

Audio DSP NHLT Endpoints Configurations: (For ADL only):

[Intel Advanced Menu/PCH-IO Configuration/HD Audio Configuration/HD Audio DSP Features Configuration/Audio DSP NHLT Endpoints Configuration](#)

On ADL, it accepts audio endpoint configurations in separate NHLT bin files depending on the NHLT settings enabled in BIOS option. Select the required features for your project:

DMIC Mono 38.4MHz	<Disabled>
DMIC Stereo 38.4MHz	<Disabled>
DMIC Quad 38.4MHz	<Disabled>
Bluetooth 38.4MHz	<Disabled>

By enabling the features in BIOS, it will load the corresponding NHLT configuration in BIOS code. For BIOS code integration user guidance, please refer to Ref019 for more details.

2.4 Action Required After Flashing BIOS/Change BIOS Settings

After flashing the new BIOS or changing ACPI table settings it is important to perform the following sequence:

1. Boot to Windows* 10.
2. Perform system reboot.
3. After reboot, perform system shutdown.

The above sequence is important to ensure that Windows* 10 reloads and uses the ACPI tables provided by a new BIOS.

S4 (hibernation) is a normal shutdown state for Windows* 10. While waking from S4 state Windows* reloads the ACPI tables from disk (hibernation file).

If BIOS is changed, ACPI tables generated by the previous BIOS version are still stored in the hibernation file on a disk. Windows* restart ensures usage of ACPI tables generated by the current BIOS. A subsequent shutdown stores these new ACPI tables in hibernation file.



3 NHLT and DMIC Blob Integration

3.1 Introduction

NHLT (Non-HD-Audio Link Table) is defined as an ACPI Data consisting of the standard ACPI Header and information about non-HD Audio endpoints supported by the system. NHLT Generator in IADK provides graphical configurator of endpoints and generates NHLT binary file.

Refer to Platform controller hub external design specification – Ref017\Ref018 for DMIC connection, clock, voltage requirements. Contact Intel Audio CE if the DMIC HW connection in customer design is different from RVP.

To integrate the generated NHLT/DMIC blob file into BIOS, refer to BIOS guidance in Ref019 for NHLT integration.

Note: The USB audio offload feature is supported on the TGL and ADL by default, so it does not require configuration in NHLT.

3.2 Pre-Installed Libraries

IADK download link: [VIP:kitid=1001873](https://www.intel.com/content/www/us/en/developer/tools/oneapi/iadk.html). If you have no access, Contact Intel Audio CE. Latest IADK version is 2.7.0 which supports ADL, TGL, EHL, ICL, CML, LKF and CNL platforms.

Python, wxPython, OpenSSL are prerequisite libraries for NHLT generator. Refer to “How to create NHLT binary file.pdf” in IADK package to install the proper version Python and wxPython.

3.2.1 Python

The recommended Python version is 3.8.6 for IADK 2.7.0. If the user has installed incorrect version of Python such as v2.7, uninstall it firstly. Python 3.8.6 download link <https://www.python.org/downloads/release/python-386/>.

%PATH% environment should be set to include Python directory.

3.2.2 wxPython

To install wxPython in Python libraries, use: “pip install -U wxPython” in the command-line console:

```
C:\Python38\Scripts>pip install -U wxPython
```


Check home or company network if you meet with network connection error.

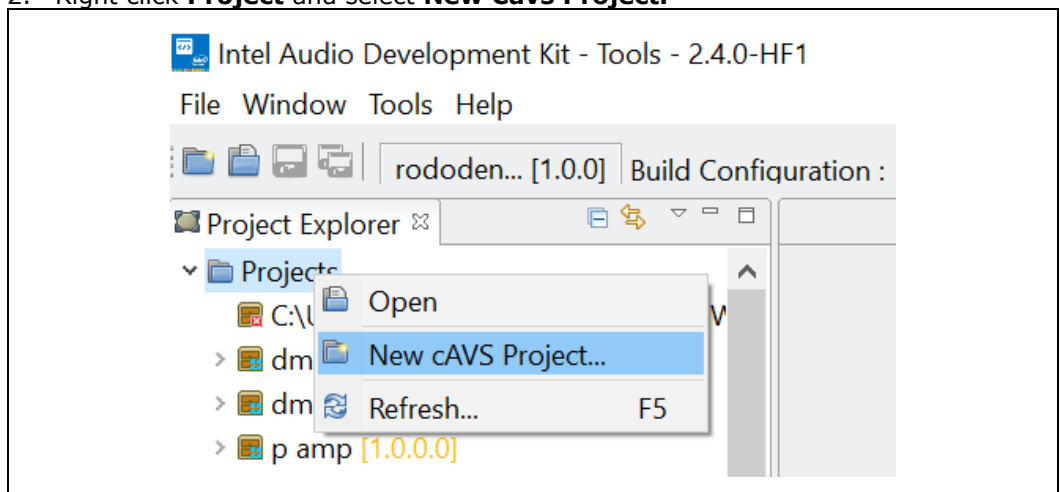
3.2.3 OpenSSL

Ensure that the installation path: "openssl.exe" is under the path
C:\GnuWin32\bin\openssl.exe

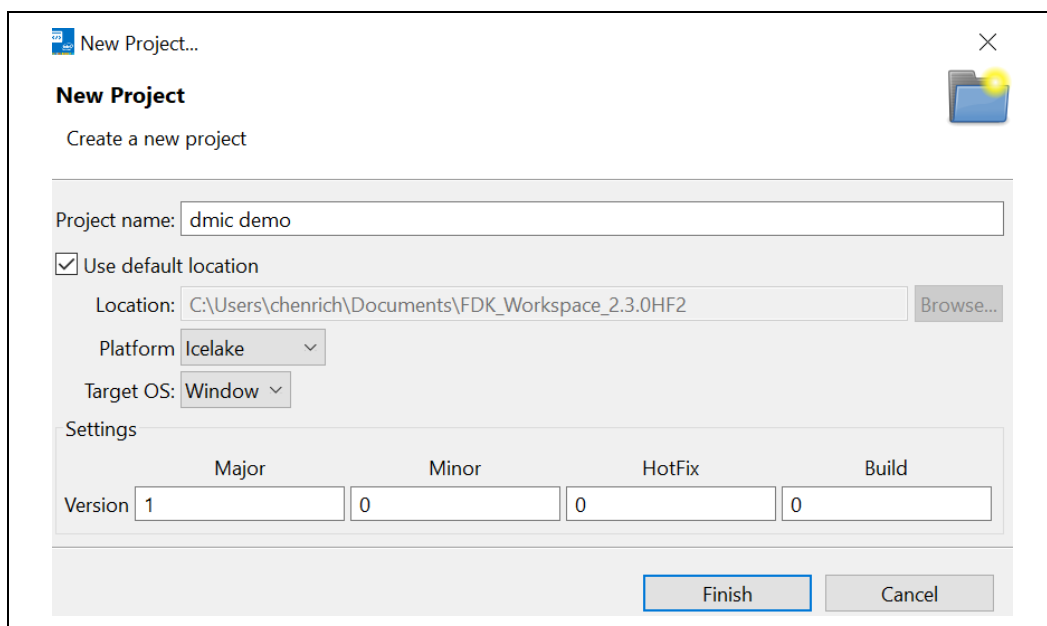
3.3 Generating nhlt.bin for DMIC

3.3.1 IADK Usage Step by Step

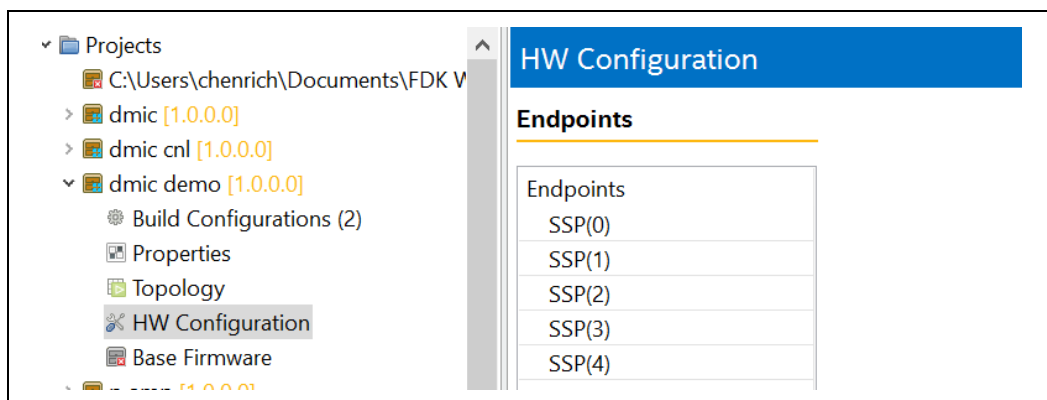
1. Install **IADK**. NHLT generation is supported after IADK 2.5 MR1. Versions equal or higher would support the same functions.
2. Right click **Project** and select **New Cavs Project**.



3. Fill the fields:
 - a. **Project Name** and **Version**.
 - b. Choose correct **Platform**.
 - c. Select **Target OS** according to target project platform.



4. Select **Project created** and double click **HW Configuration**.



5. Click **Add Endpoint** to create new endpoint.
 - a. Choose the preferred link type.
 - b. To create configuration for DMIC connecting to PCH, choose Endpoint as **PDM**.
 - c. Select **Link type** as **PDM**.

HW Configuration

Endpoints

Endpoints
SSP(0)
SSP(1)
SSP(2)
SSP(3)
SSP(4)
SSP(5)
PDM
HD-A

+ Add Endpoint

HW Configuration

EndpointsEndpoint Configuration

Endpoints	Link type
SSP(0)	<div> <div>▼</div> <div>HD-A</div> <div>PDM</div> <div>SSP</div> <div>SoundWire</div> </div>
SSP(1)	
SSP(2)	
SSP(3)	
SSP(4)	

6. Configure the following information according to the target project configurations:
 - a. **Platform ID:** The PCH ID according to target project SoC PCH info.
 - b. **I/O Clock:** The PCH XTAL output clock.
Refer to platform PDG or PCH EDS to get PCH XTAL clock.
Confirm with account platform CE and HW CE if not clear about the previous two configurations.
 - c. **Number of channels:** The number of MIC channel on the target project.

Note: If there are three microphones attached, two on PDM0 and one on PDM1, then you must choose 4 channels in **Number of channels** configuration. Paired DMIC connection is recommended, IADK uses PDM0 for 2 DMIC by default.

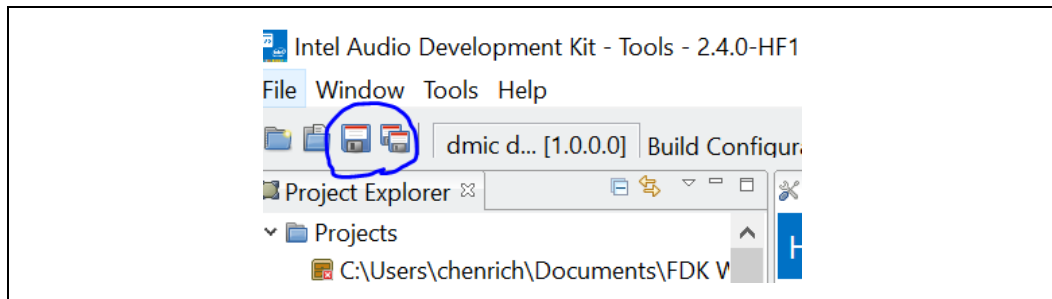
7. Microphone array and geometry configuration.

- a. **Config Type:** choose if **Microphone array** is in use on the target project. **Microphone array** checkbox activates the following array type configuration.
 - i. **Array Type:** choose if the Microphone array placement matches one of the pre-defined geometry configurations or choose **Vendor defined** to customize your own.
 - ii. **Number of microphones:** Choose the microphone number on **MIC array**.
 - iii. **Horizontal Offset(mm):** Put the distance offset of microphone components.

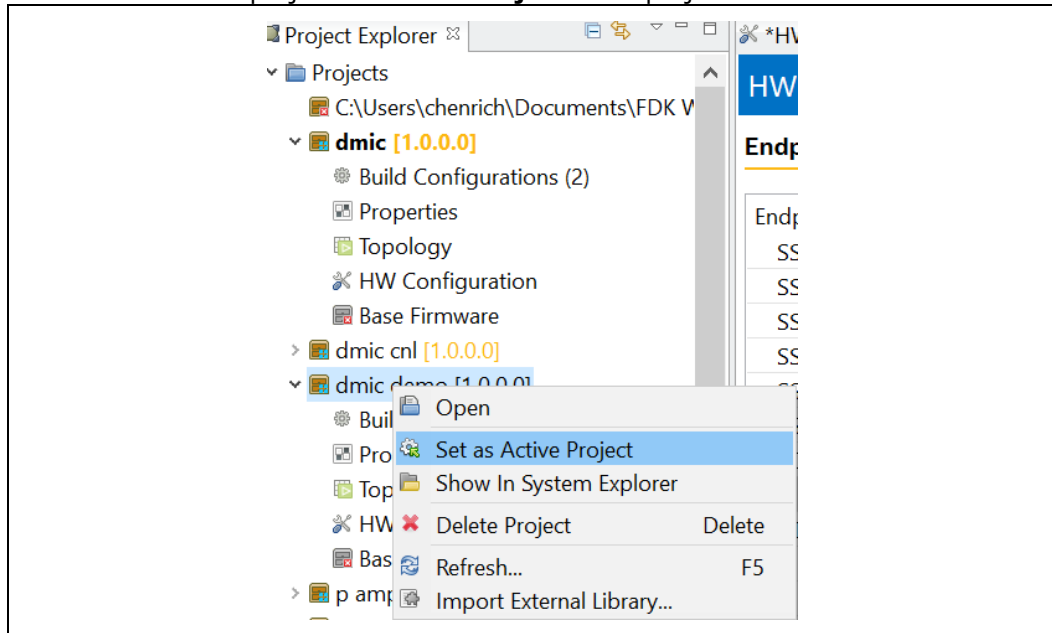
Note: If microphone placement is horizontal linear then put the distance offset of microphone component to the center of the device as plus-minus millimeter values.

8. For further details to define Microphone Array Geometry Descriptor Format, refer to Ref004.

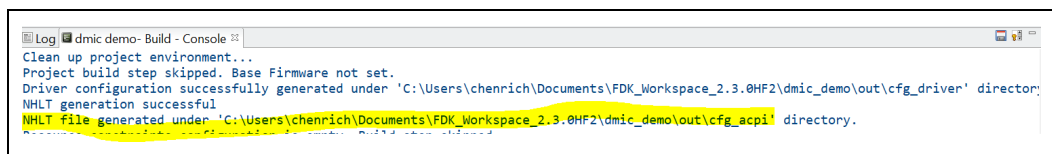
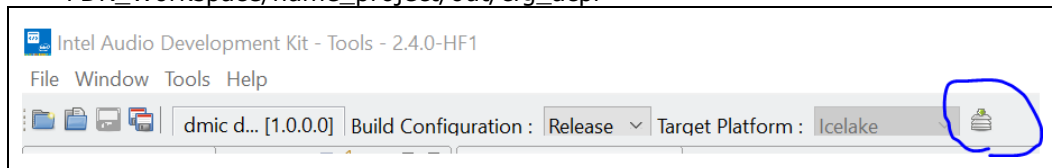
9. Click **Save** to retain settings in the hwconfiguration.xml file in the following location: FDK_Workspace/name_project/metadata.



10. Set the created project as **Active Project** if the project is inactive.



11. Build the project to generate nhlt.bin file. The nhlt.bin file will be in the path "FDK_Workspace/name_project/out/cfg_acpi"





3.3.2 Verifying nhlt.bin

After generating the nhlt.bin file, verify the bin file to target device, and check DMIC CLK on the device.

1. Copy nhlt.bin file to device, path:
C:\windows\system32\cAVS\nhlt_FILE_NAME.bin
2. Add registry key to override the value.
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\IntcOED\Parameters]
3. "NhltOverridePath"="\SystemRoot\System32\cAVS\nhlt_FILE_NAME.bin"
Reboot system
4. Measure DMIC CLK and check signal.

If the microphone is working as expected, then the nhlt.bin file is ready for BIOS integration. Need to integrate the generated NHLT/DMIC blob file into BIOS, refer to BIOS guidance in Ref019 for BIOS integration. Contact the BIOS CE if any assistance is required.

3.4 Generating nhlt.bin for BT® Offload

Note: For ICL, CML v2 and TGL only

The default BT® audio settings are integrated into Intel RVP BIOS, and it should be suitable for most of BT® headset device in our experience. Add your customized PDM (DMIC configuration) into the default nhlt.bin file from RVP.

The default NHLT from RVP is available in the following Bring Up Guide files:

- CML v2
- ICL
- TGL

Note: For ADL only

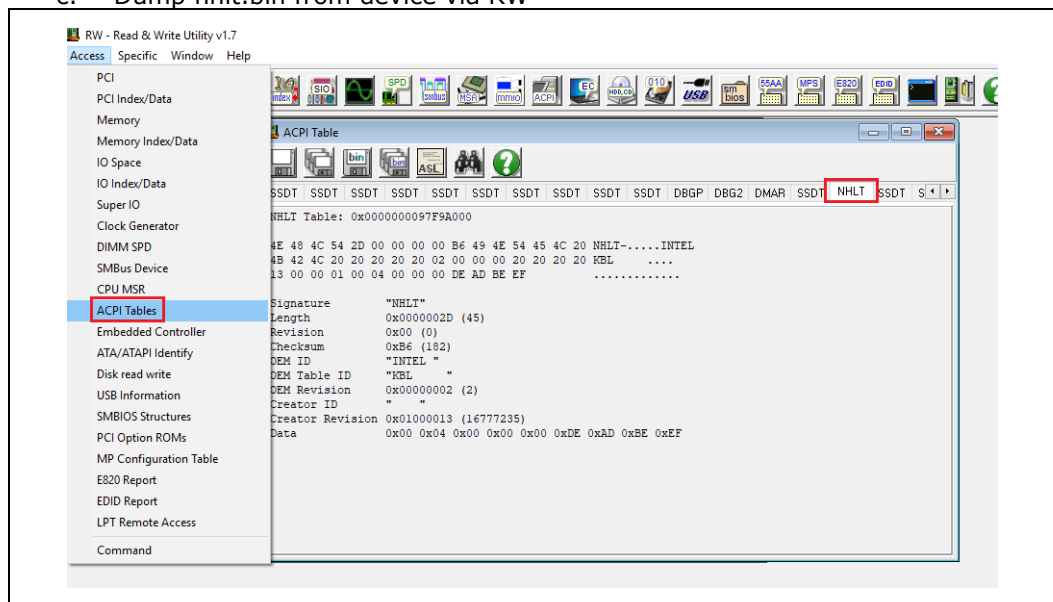
Starting from ADL, the BIOS code architecture accepts BT® offload audio setting and DMIC configuration in separate NHLT bin files depending on the NHLT settings enabled in BIOS option. There's no need to combine BT offload and DMIC configuration in single NHLT file. Follow the step of Audio DSP NHLT Endpoints Configurations: (For ADL only) in [Section 2.3](#).

The default NHLT from ADL RVP is available in Bring Up Guide file ADL_NHLT.zip:

- 2 DMIC with 38.4MHz CLK: NhlConf1DmicX2_38_4.bin
- 4 DMIC with 38.4MHz CLK: NhlConf2DmicX4_38_4.bin
- BT with 38.4MHz CLK: NhlConf3Bt_38_4.bin

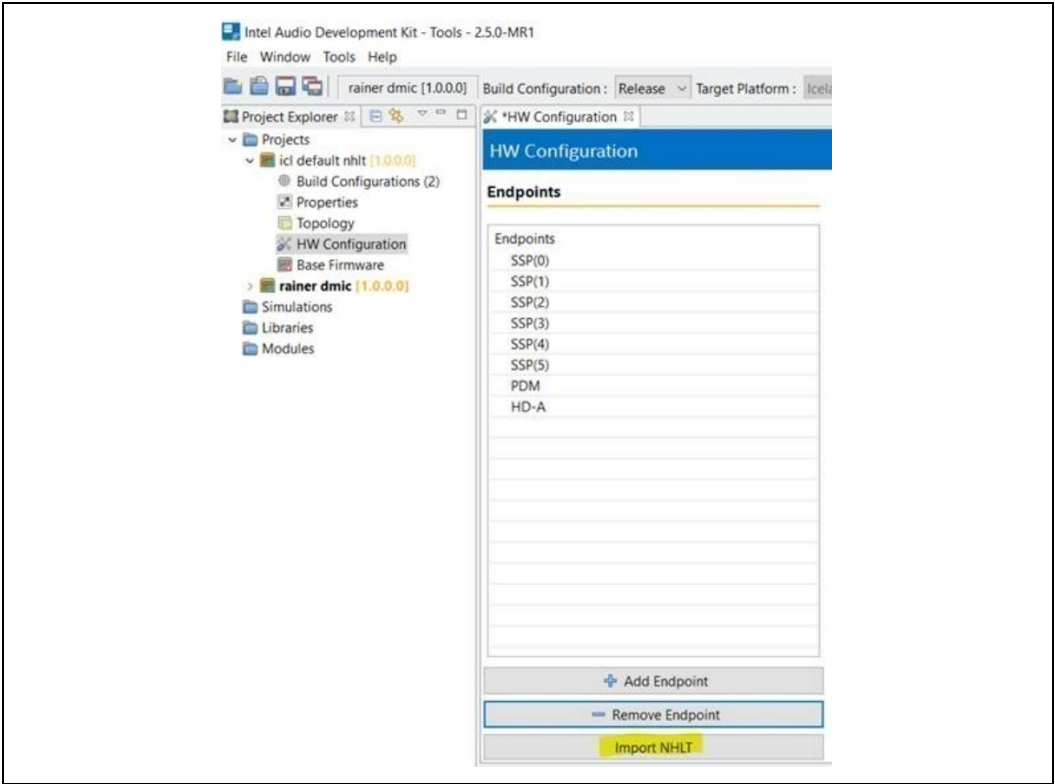
3.4.1 IADK Usage Procedure

1. Retrieve the default nhl.bin file.
The method to retrieve the default nhl.bin:
 - a. Use internal **NHLT**
 - b. **Boot** into OS
 - c. Dump nhl.bin from device via RW

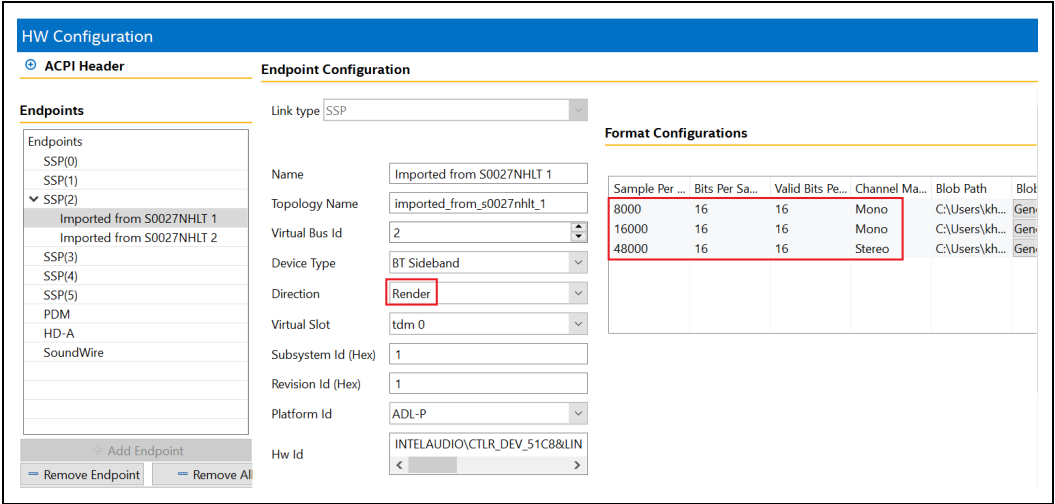


Note: Configuration may change on different platforms.

2. Integrate DMIC configuration into default nhl.bin
 - a. Create a **New project** in IADK.
 - b. Import the retrieved nhl.bin from the previous step.



c. BT® configuration is for both render and capture and are included after nhlt.bin imported.



HW Configuration

ACPI Header | **Endpoint Configuration**

Endpoints

Link type: SSP

Name: Imported from S0027NHLT 2

Topology Name: imported_from_s0027nhlt_2

Virtual Bus Id: 2

Device Type: BT Sideband

Direction: **Capture**

Virtual Slot: tdm 0

Subsystem Id (Hex): 1

Revision Id (Hex): 1

Platform Id: ADL-P

Hw Id: INTELAUDIO\CTLR_DEV_51C8&LIN

Format Configurations

Sample Per ...	Bits Per Sa...	Valid Bits Pe...	Channel Ma...	Blob Path	Blot
8000	16	16	Mono	C:\Users\kh...	Geni
16000	16	16	Mono	C:\Users\kh...	Geni

- d. For PDM (DMIC configuration), refer to steps in [Section 3.3.1](#) to fit the DMIC design.

***HW Configuration**

HW Configuration

Endpoints

Endpoints

SSP(0)

SSP(1)

SSP(2)

Imported from nhlt_icl_dmic4ch_bt 1

Imported from nhlt_icl_dmic4ch_bt 2

SSP(3)

SSP(4)

SSP(5)

PDM

Imported from nhlt_icl_dmic4ch_bt 0

HD-A

- e. Follow the steps mentioned in [Section 3.3.2](#) to verify BT® offload function and integrate into BIOS.

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4 *Driver/Application Installation*

Ensure BIOS settings are configured before Intel® SST Driver installation.

The following procedure to install the Intel® SST Driver is required.

4.1 Driver Installation

Use the "Have Disk..." method to install the following drivers.

Browse to the unzipped Platform Milestone release folder location (for example, Intel®_Smart_Sound_Technology_<Platform>_<Milestone>_Release_vx.xx.xx.xxx\) and perform the following step:

1. Install BUS driver (IntcAudioBus.inf) from the subfolder Drivers over High Definition Audio Controller in the Device Manager.
 - a. Name of the device before installing driver: High Definition Audio Controller.
 - b. Name of the device after installing the driver: Intel® Smart Sound Technology (Intel® SST) Audio Controller.
2. Install OED driver (IntcOED.inf) from the subfolder Drivers over Intel High Definition DSP in the Device Manager.
 - a. Name of the device before installing driver: Intel High Definition DSP.
 - b. Name of the device after installing the driver: Intel® Smart Sound Technology (Intel® SST) OED.

Optional step only if DMIC is connected to PCH:

3. Install DMIC driver (IntcDMic.inf) from the subfolder Drivers over Digital microphone device in the Device Manager
 - a. Name of the device before installing driver: Digital Microphone Device.
 - b. Name of the device after installing the driver: Intel® Smart Sound Technology (Intel® SST).

Optional step only if SDW interface enable instead of HD audio:

4. Install SDW driver (IntcSDW.inf) from the subfolder Drivers over SDW master device in the Device Manager.
 - a. Name of the device before installing driver: SoundWire* device.
 - b. Name of the device after installing driver: Intel® Smart Sound Technology (Intel® SST).

Optional step only for Bluetooth® audio offload enabling (For ICL, CML v2 and TGL only)

5. Install Bluetooth® Audio driver (IntcBtAu.inf) from the subfolder Drivers over Bluetooth® device in Device Manager.
 - a. Name of the device before installing driver: There is no Bluetooth® device under Intel® Smart Sound Technology (Intel® SST) OED
 - b. Name of the device after installing the driver: Intel® Smart Sound Technology (Intel® SST).

Optional step only for USB audio offload enabling (for TGL only)

6. Install UAOL driver (IntcUSB.inf) from the subfolder Drivers over UAOL device in Device Manager.
 - a. Name of the device before installing driver: There is no USB device under Intel® Smart Sound Technology (Intel® SST) OED.
 - b. Name of the device after installing the driver: Intel® Smart Sound Technology (Intel® SST).

NOTES:

1. For QS samples, install ProductionFW driver. For ES samples, install the NonProductionFW driver. Otherwise, Yellow Band will be seen on OED device.
2. Install the appropriate Intel® SST driver based on the platform that the drivers are being installed on (for example, ICL Intel® SST drivers in ICL platforms).
3. For TGL system installed with 20H1 OS, install GFX driver before SST driver because GFX will enable SGPC (Shared Graphics Power Component). Otherwise, there will be non-SGPC HDA hidden device in the Device Manager.

4.1.1 Checking the Driver Version

To check the Intel® SST Driver version:

1. Open the **Device Manager**.
2. Click **Sound, Video, and Game controllers'** arrow to open the list of audio/sound devices.
3. Double click the device named as **Intel® Smart Sound Technology**.
4. Select **Driver** tab and verify that the **Intel® SST** driver version is correct
5. Double click **HW Audio Codec** device
6. Select **Driver** tab and verify that the Codec driver version is correct



5 Basic Audio DSP Features Check

5.1 Playback on System Pin

1. Prepare .wav sound file (for example 24bit, 48khz, stereo)
2. Open Windows* Media Player
3. Select and play the .wav sound file
4. Check if the sound is audible
5. Try **different sound file extensions (.mp3, .aac)**.

5.2 Intel® WoV with Cortana*

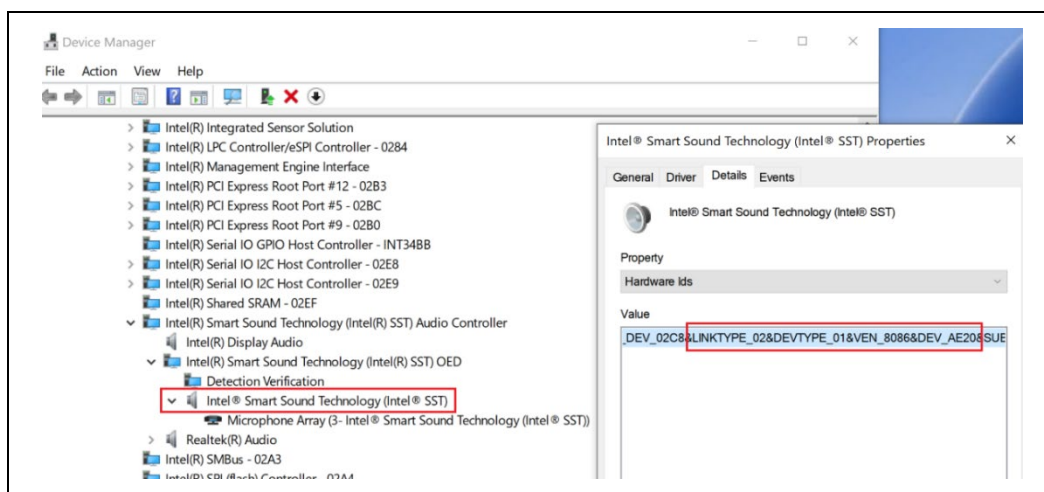
1. Go to Cortana* Settings and turn on the options:
 - a. 'Let Cortana* respond to "Cortana"'
 - b. 'Use Cortana* even when my device is locked.'
2. Let system enter Connected Standby mode.
3. Check if system wakes up when called "**Cortana**".

5.3 Playback on Offload Pin

1. Prepare .wav sound file (for example 24bit, 48khz, stereo)
2. Open Windows* 10 **Groove Music**.
3. Select and play the .wav sound file
4. Check if the sound is hearable
5. Try **different sound file extensions (.mp3, .aac)**.

5.4 Recording Volume on DMIC to PCH

1. Open Windows*10 **Voice Recorder**.
2. Click **Record** button and start to record.
3. Open **Recording** page in **Sound** from the speaker icon in right-down corner.
4. Try to adjust the volume bar to check recording volume.
5. Check if recording volume take effect as expectation or not.
6. Check the description of HWID in properties page of Device Manger as well. The full string of DMIC PDM endpoint descriptor is as shown below,
 - a. **LINKTYPE_02&DEVTYPE_00&DEV_AE20 || LINKTYPE_02&DEVTYPE_01&DEV_AE20** (DEVTYPE_01 is required due to old BIOS RC code compatibility, but BIOS RC code may change to 00 in the future)



Note: Since Intel DMIC driver does not provide analog AGC when DMIC is connected to PCH, you will require 3rd party SW APO to support SW gain control for volume adjustment.

5.5 Bluetooth® Audio on Offload Pin

- ADL + Intel® Wi-Fi 6E AX211: Support Bluetooth HFP and A2DP audio offload. Bluetooth A2DP audio offload can support SBC and AAC codec.
- TGL-R + Intel® Wi-Fi 6 AX201: Support Bluetooth HFP and A2DP audio offload. Bluetooth A2DP audio offload can support SBC codec.
- TGL-U/H + Intel® Wi-Fi 6 AX201: Support Bluetooth HFP audio offload.

Note: Refer to **Ref002** – “Bluetooth® Audio Offload Technical Advisory” for more details.

1. For TGL, contact BIOS member to ensure GPIOs for BT® Offload (**GPPC_A_7** and **GPPC_A_10**) are configured as **GPIO mode**.

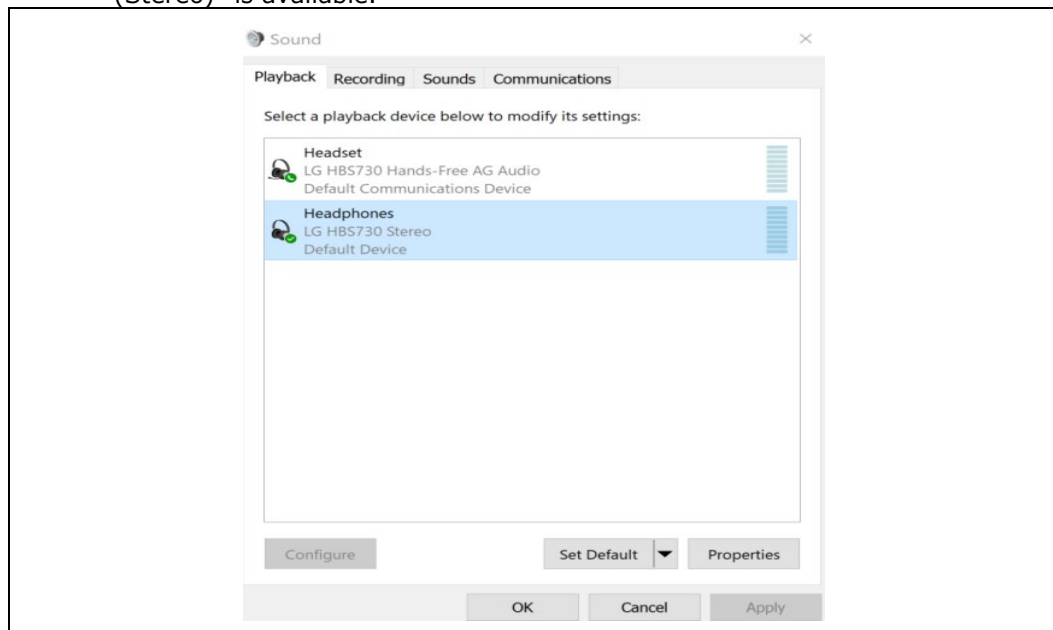
For ADL, ODM should not expose I2S2 externally

Signal Name	GPIO	GPIO Community	Power Well	Voltage Tolerance	Native Function 1	Native Dir 1	Native Function 2	Native Dir 2
GPP_R4 / HDA_RST# / I2S2_SCLK / DMIC_CLK_A0	GPP_R4	5	VCCPRIM_1P8 or VCCPRIM_3P3	1.8 V or 3.3 V	HDA_RST#	out	I2S2_SCLK	inout
GPP_R5 / HDA_SD11 / I2S2_SFRM / DMIC_DATA0	GPP_R5	5	VCCPRIM_1P8 or VCCPRIM_3P3	1.8 V or 3.3 V	HDA_SD11	inout	I2S2_SFRM	inout
GPP_R6 / I2S2_TXD / DMIC_CLK_A1	GPP_R6	5	VCCPRIM_1P8 or VCCPRIM_3P3	1.8 V or 3.3 V			I2S2_TXD	out
GPP_R7 / I2S2_RXD / DMIC_DATA1	GPP_R7	5	VCCPRIM_1P8 or VCCPRIM_3P3	1.8 V or 3.3 V			I2S2_RXD	in

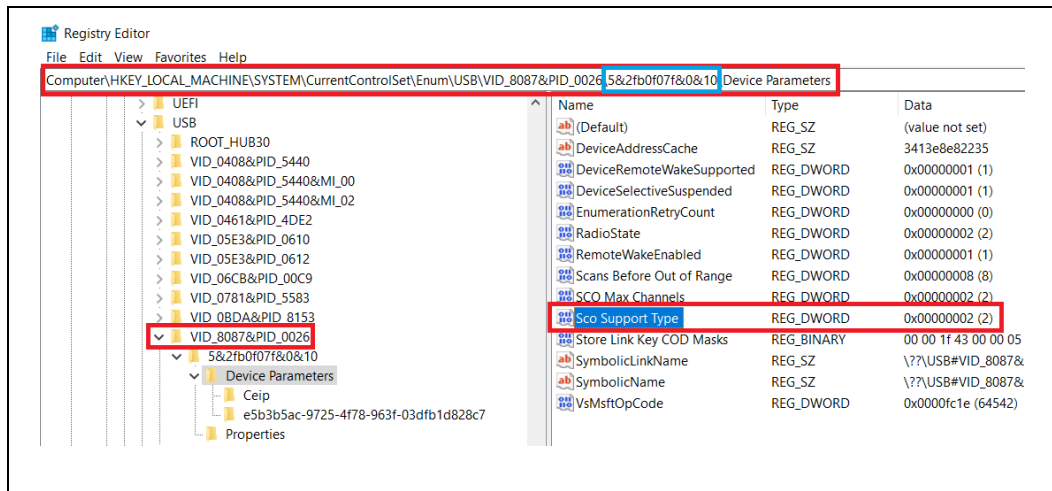
Recommend following ADL RVP Design as below:

Intel		
Primary Well Group R (Per-Family 1.8 V or 3.3 V) GPIO Community 5		
GPP_R0	GPP_R0 / HDA_BCLK / I2S0_SCLK / DMIC_CLK_B0 / HDAPROC_BCLK	Native F1
GPP_R1	GPP_R1 / HDA_SYNC / I2S0_SFRM / DMIC_CLK_B1	Native F1
GPP_R2	GPP_R2 / HDA_SDO / I2S0_TXD / HDAPROC_SDO	Native F1
GPP_R3	GPP_R3 / HDA_SDI0 / I2S0_RXD / HDAPROC_SDI	Native F1
GPP_R4	GPP_R4 / HDA_RST# / I2S2_SCLK / DMIC_CLK_A0	Native F1
GPP_R5	GPP_R5 / HDA_SDI1 / I2S2_SFRM / DMIC_DATA0	GP-In
GPP_R6	GPP_R6 / I2S2_TXD / DMIC_CLK_A1	GP-In
GPP_R7	GPP_R7 / I2S2_RXD / DMIC_DATA1	GP-In

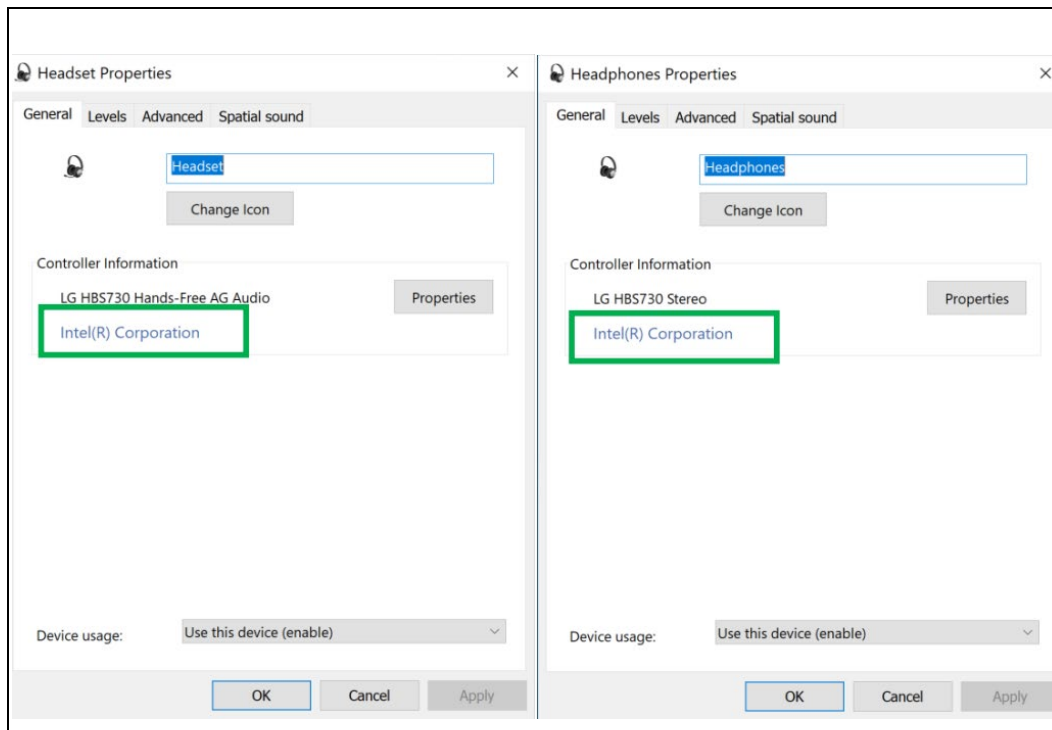
2. Follow [Section 2.3](#) to configure BT® Audio offload in BIOS.
3. For audio device setup:
 - a. Pair with Bluetooth® Headset.
 - b. Go to **Playback** tab in **Sound**.
 - c. Verify that the Bluetooth “Headset (Hands-Free)” and Bluetooth “Headphones (Stereo)” is available.



4. BT® driver will query the BIOS and write into the registry with the appropriate audio offload support value, applies to both HFP and A2DP:
 - a. [HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Enum\USB\VID_<VID> &PID_<PID>\<DEV_ID>\Device Parameters]
 - i. If BT® Audio Offload is to be disable, “Sco Support Type” <0x0>
 - ii. If BT® Audio Offload is to be enable, “Sco Support Type” <0x2>



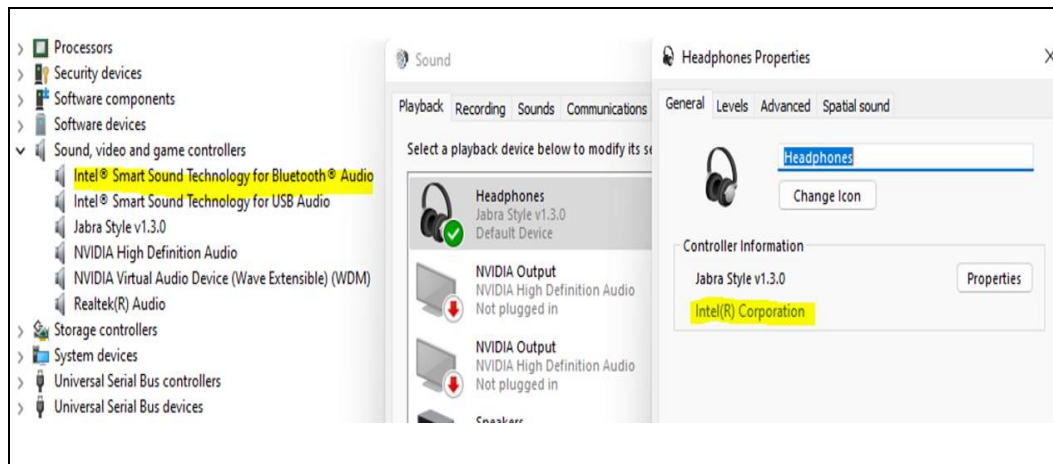
5. Check the **Controller information** from **Sound > Playback > Headset/Headphones Properties**, and check if “**Intel® Corporation**” instead of “Microsoft” if it is running on the offload pin.



12. Since the BT® Audio link is not standard HD audio, there are necessary configurations in NHLT as described in [Section 3.4](#). An extra Intel® SST child device would be under Intel OED if right NHLT integrated into BIOS as shown in figure below.

Check the description of HWID in properties page of Device Manager as well. The full string of BT® Endpoint Descriptor is as below,

a. LINKTYPE_03&DEVTYPE_00&DEV_AE30



13. If there is Bluetooth - UsbScoDataTransportLayer WHQL failure for BT offload enabled system, please contact Intel Bluetooth and Audio CE for details.

5.6 USB Audio Offload

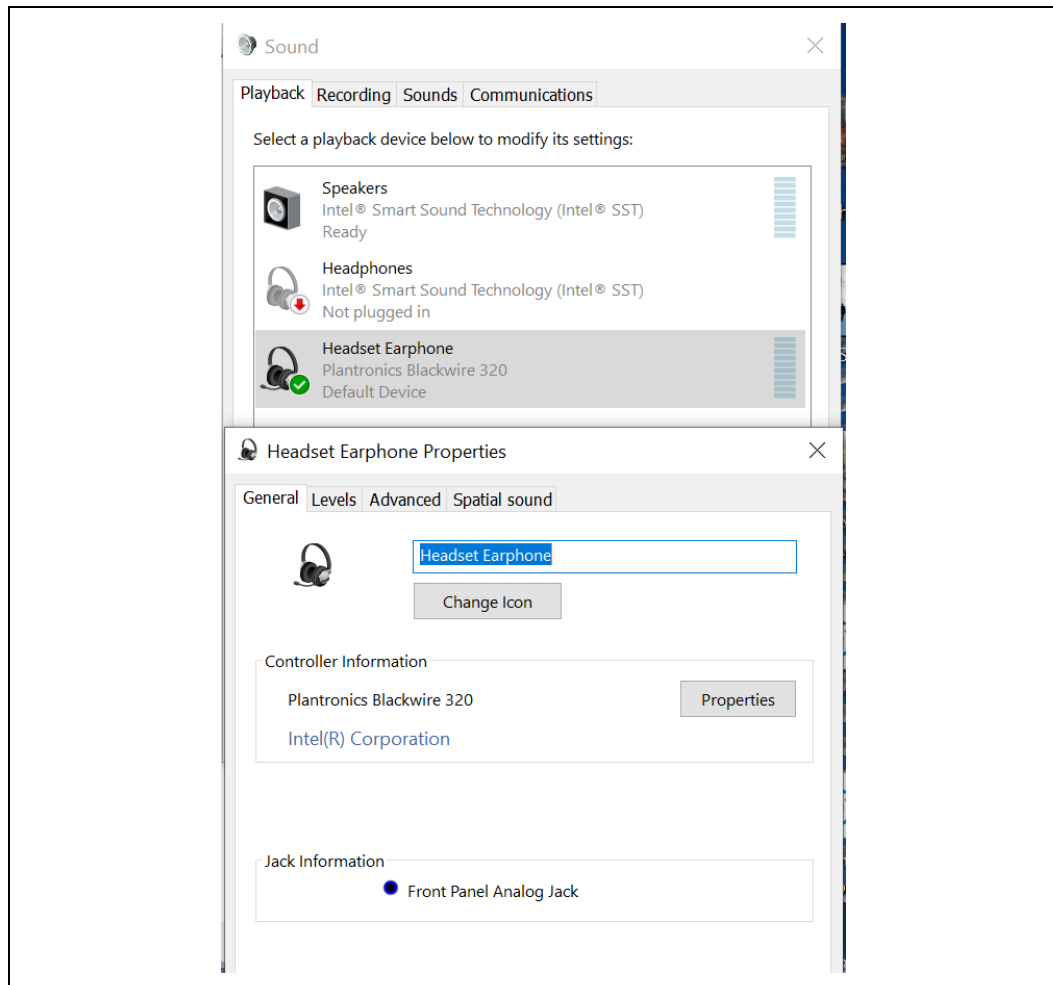
Note: Refer to **Ref012** – “USB Audio Offload Technical Advisory” for more details.

USB audio offload is supported only on **UAC 1.0 devices**, and not on UAC 2.0 or other devices. Customers can use USB View tool from Microsoft* WDK to determine the type of USB device (UAC 1.0 or UAC 2.0) connected to the system.

For TGL, USB Audio is offloaded to DSP by default, refer to **Ref013** for UAOL enable/disable in BIOS. For ADL, follow [Section 2.3](#) to enable/disable UAOL. Additionally, BIOS must set **HCCPARAMS2.GSPC** on 1 (When GSPC is 0, then MSFT inbox driver will not expose interface to OED and IntcUSB will not be enumerated).

Refer to items below to check UAOL enable successfully or not.

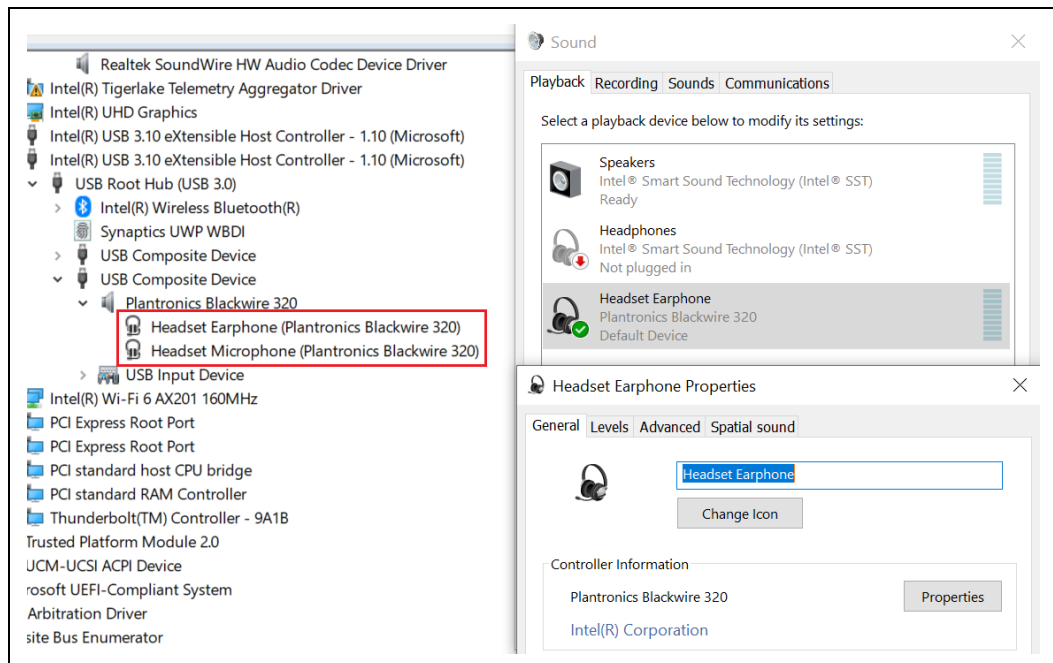
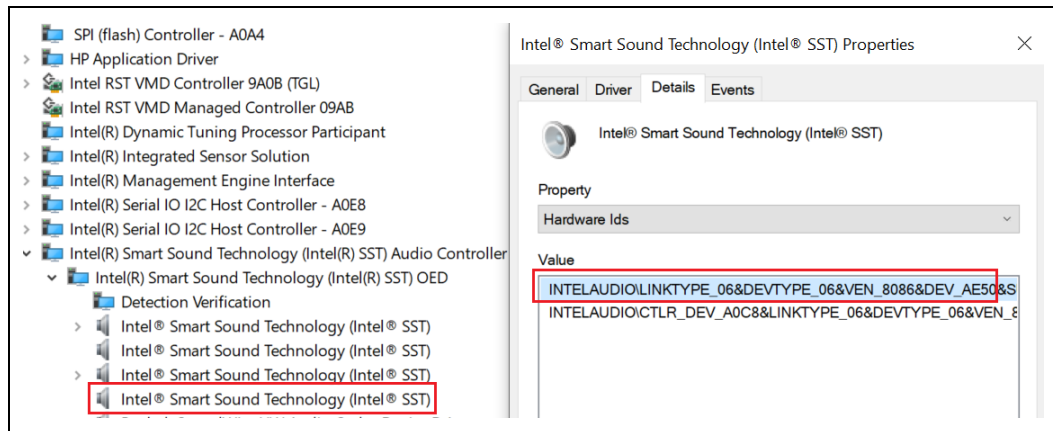
1. After the driver of UAOL installed, check the **Controller information** from **Sound > Playback > Headset Properties**, and check **Intel® Corporation** if it is running on USB audio offload pin.



2. Check if the USB headset device is as child device of Intel® SST OED.

Note: USB headset endpoints will still appear under xHCI in the device manager. Check the description of HWID in properties page of the Device Manager as well. The full string of USB Audio device descriptor is as shown below,

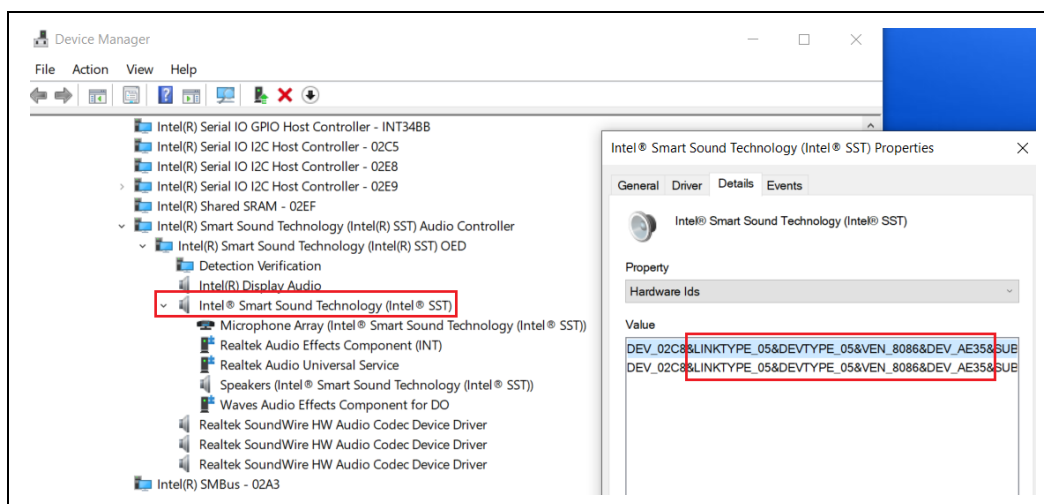
a. **LINKTYPE_06&DEVTYPE_06&DEV_AE50**



5.7 SoundWire* Audio Device

In SDW design, there is one SDW audio device as a child device under Intel OED after driver of IntcSDW is installed. Check the description of HWID in properties page of Device Manager as well. The full string of SDW endpoint descriptor is as below,

1. LINKTYPE_05&DEVTYPE_05&DEV_AE35



5.8 Multi-Voice Assistant

Note: Refer to **Ref006** – “MVA enabling guidance” for more details. MVA extension inf and Intel® SST driver binaries are separate links in Microsoft partner web site and needs to be resold separately. MVA extension version matches the DetectionVerificationDrv.

For Multi-Voice Assistant enabling, configurations in BIOS, MVAExtension.Inf and Windows* settings are required.

1. BIOS:

Follow [Section 2.3](#) to configure BIOS, Set **VAD API Mode** as **Windows* 10 Voice Activation**

Intel Advanced Menu → PCH-IO Configuration → HD Audio Configuration → HD Audio DSP Features Configuration

- WoV (BIT 0) = [TRUE]
- VAD API Mode (BIT 8) = [Windows 10 Voice Activation]

2. MVA Extension Inf:

Define configuration of VAs for a given design in **IntelMvaExtension.inf**

```
; Default placed in VALocaleMap registry key. By default, Alexa and Cortana supported in all locales
[IntelMva.EnableMva_Default]
HKR,VALocaleMap,VAEventIDs,0x00010000,%HeyCortanaEventGuid%,%AlexaEventGuid%

; OEM DLL will read VALocaleMap to determine what VAs to support based on current system locale.
; China Chinese (Simplified) (0804) only supports Cortana and Xiaowei
; VAEventIDs value will be place in locale language id subkey: VALocaleMap\0804.
[IntelMva.EnableMva_zh-CN]
HKR,VALocaleMap\zh-CN,VAEventIDs,0x00010000,%HeyCortanaEventGuid%,%XiaoweiEventGuid%
```

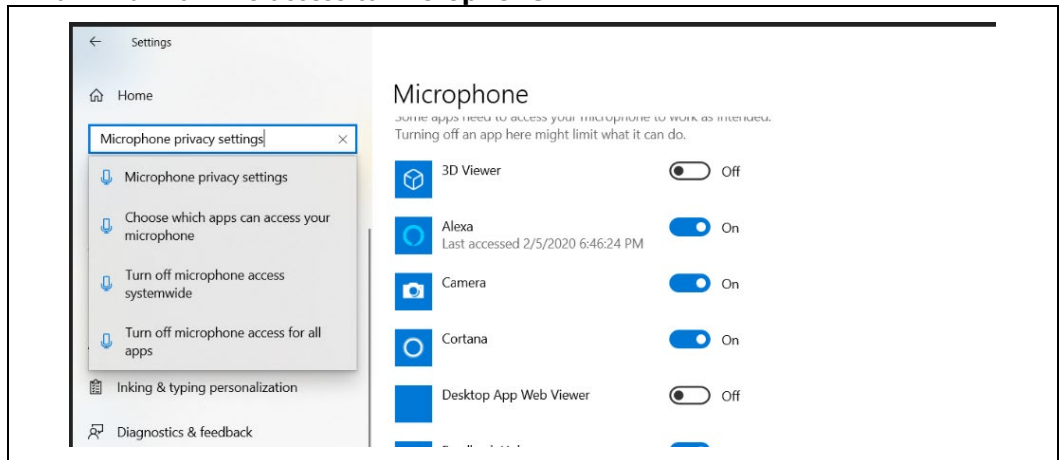
Check the MVA extension installation and version by command with Administrator right "**dism /Online /Get-Drivers /Format:table |findstr mva**".

```
PS D:\> dism /Online /Get-Drivers /Format:table |findstr mva
pem17.inf | intelmvaextension.inf | ? | Extension | Intel(R) Corporation | 2020/12/3 | 1.0.1785.0
PS D:\>
```

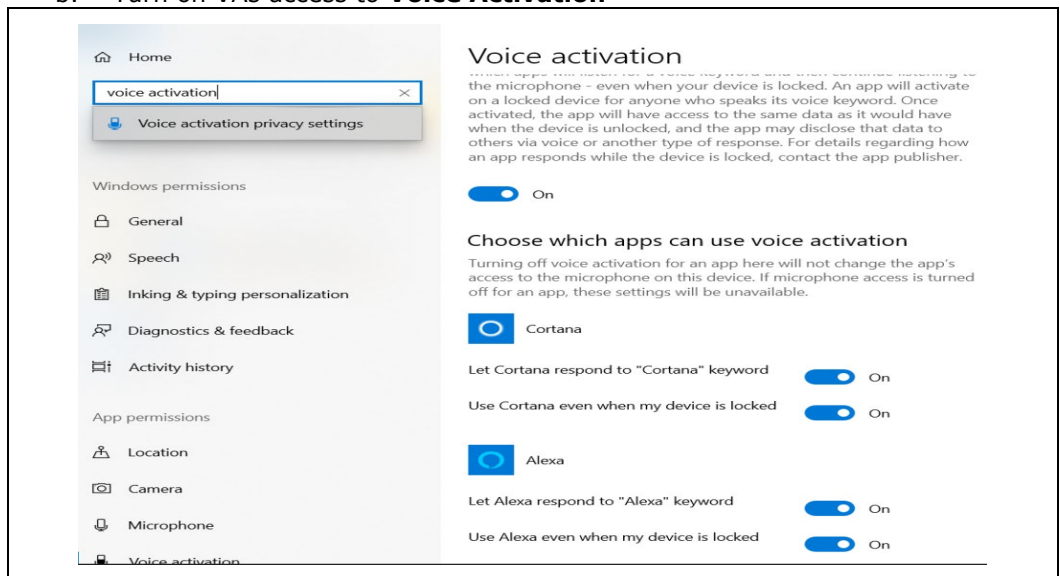
3. Windows* Settings:

Turn on VAs access right to **Microphone** and **Voice Activation**, Enable capture audio enhancements.

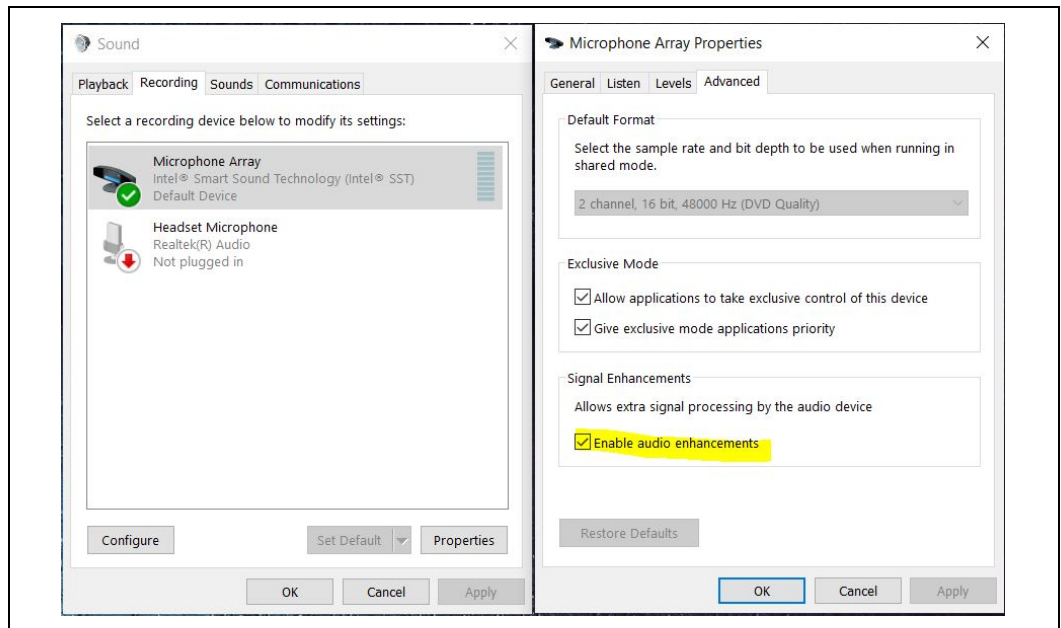
a. Turn on VAs access to **Microphone**



b. Turn on VAs access to **Voice Activation**



c. Select **Sound** Control Panel > **Recording** > **Microphone Array** > **Properties** > **Advanced**, and check **Enable audio enhancements** checkbox.



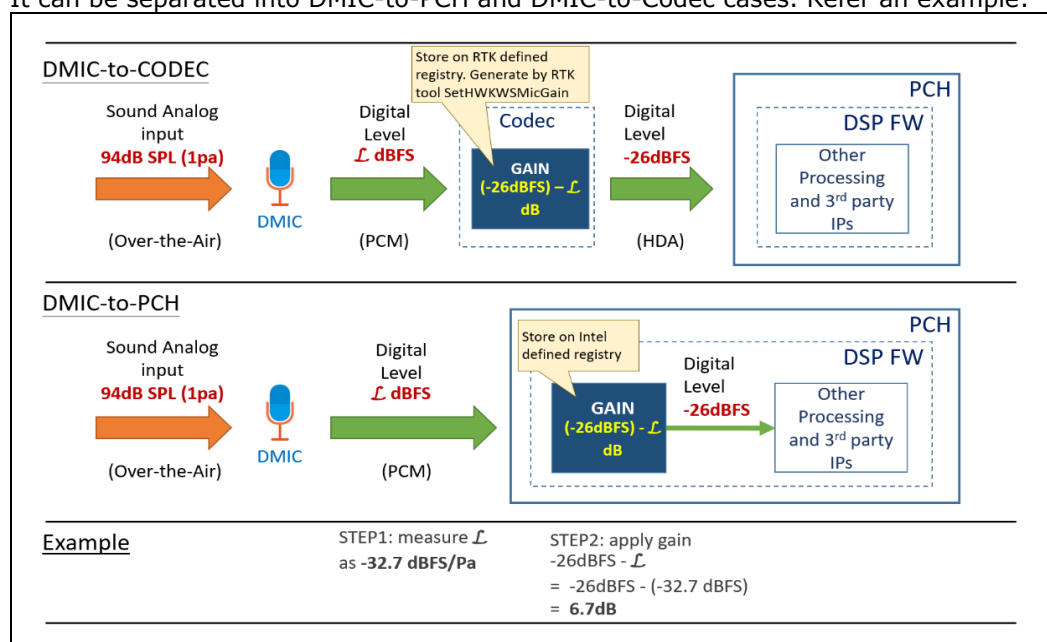
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6 -26dBFS MIC Sensitivity Calibration

6.1 -26dBFS Introduction

The -26dBFS/Pa calibration process is to let the system have -26dBFS/Pa input sensitivity. To achieve it, we need to add a proper gain on DSP (for DMIC-to-PCH) or codec (for DMIC-to-Codec) designs.

It can be separated into DMIC-to-PCH and DMIC-to-Codec cases. Refer an example:



6.2 SPET and MIC Sensitivity Calibration Tool

Intel SPET Tool and Documents: (contact Intel Audio CE to enable access and get latest SPET download link)

- SPET v1.0.2474.0
<https://platformsw.intel.com/CollateralDownload.aspx?key=COL.1025986>
- SPET v1.0.2582.0
<https://platformsw.intel.com/ddrivers.aspx?kitnumber=1000547>
- SPET Plugin:
<https://platformsw.intel.com/CollateralDownload.aspx?key=COL.1024447>
- Intel® Speech Platform Evaluation Toolset Test Guide
<https://cdrdv2.intel.com/v1/dl/getContent/595819>

For DMIC-to-Codec cases, contact RTK to get the gain adjust tool-SetHWKWSMicGain.

6.3 MIC Sensitivity Calibration Process

1. Follow [595819-intel-spet-test-guide](#) to setup SPET lab, or run by PAL lab.
2. Run SPET, make sure it passes phase, frequency response, SDNR, sensitivity, TCLW.

The SPET's microphone sensitivity page shows the suggested gain to compensate.

SPET 1.0.2043.0 - Copyright © 2016-2019 Intel Corporation

Platform assessment phase: Start

Current Step: 5. Mic. sensitivity

Input directory: C:\Intel\SPET_History\2019-08-06\16-58-13_LASUS_UX563\assessment\MicSensitivity

Metric status: Calculated

REF Microphone Sensitivity (dBFS): -7.6125

Mic.#1: -30.3199 dBFS/Pa
Mic.#2: -29.84 dBFS/Pa
Mic.#3: -34.6292 dBFS/Pa
Mic.#4: -36.2038 dBFS/Pa

Mics variation: 6.36 dB
Suggested gain to achieve -26dBFS/Pa: +6.70 dB

Extension INF snippet for Intel DMIC driver gain configuration:
[IntelDmicGainExt.AddReg]
HKR,GlobalSettings\Device0,Gain,0x00010001,0x6B333

average mic input sensitivity = 32.748225 dBFS/Pa
=> (cut of some digits) => -32.7 dBFS/Pa
-26 dBFS/Pa - (-32.7 dBFS/Pa) = 6.7 dB

6.4 Calibrate MIC Sensitivity for DMIC-to-PCH Design

1. Get the suggested gain from the SPET MIC sensitivity test page

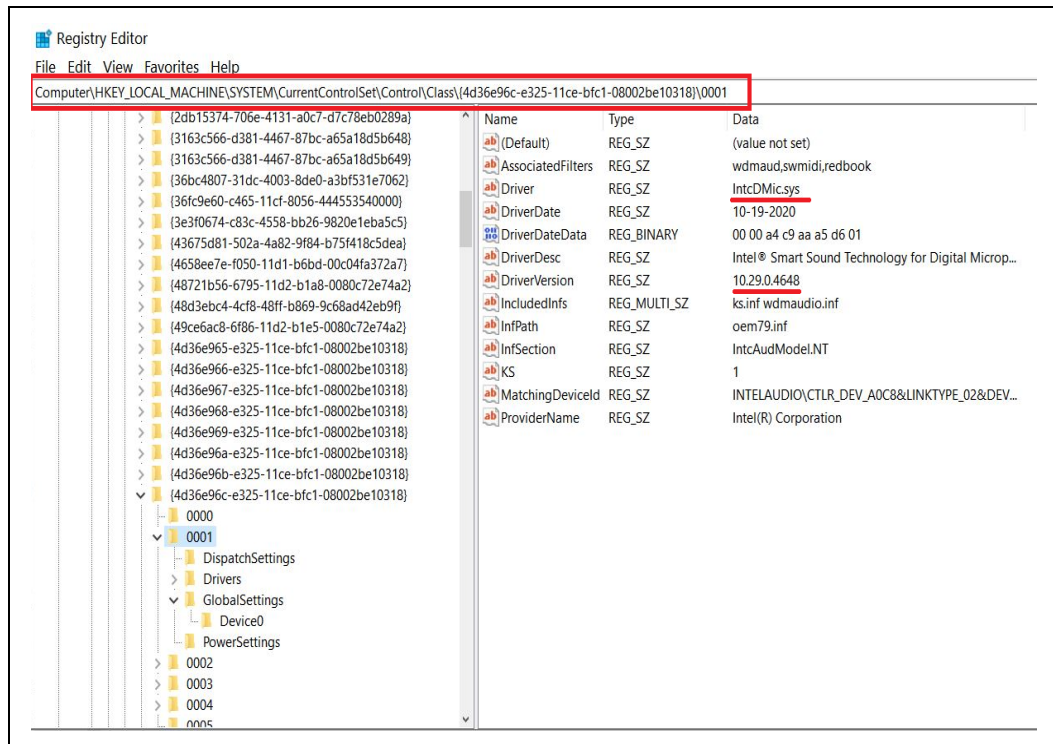
REF Microphone Sensitivity (dBFS): -7.2934

Mic.#1: -30.5523 dBFS/Pa
Mic.#2: -30.5398 dBFS/Pa

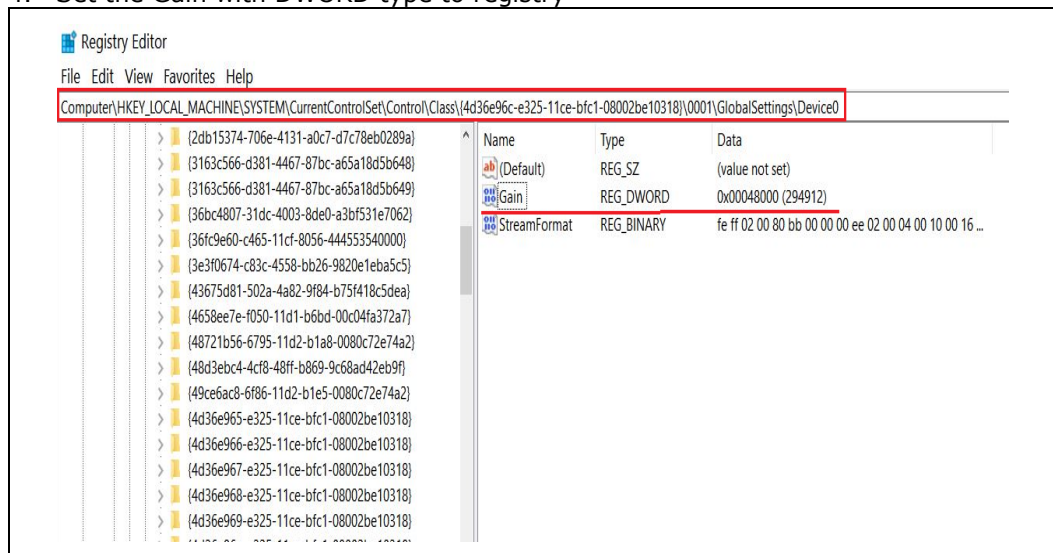
Mics variation: 0.01 dB
Suggested gain to achieve -26dBFS/Pa: +4.50 dB

Extension INF snippet for Intel DMIC driver gain configuration:
[IntelDmicGainExt.AddReg]
HKR,GlobalSettings\Device0,Gain,0x00010001,0x48000

2. Set the gain to DMIC in registry table
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Class\{4d36e96c-e325-11ce-bfc1-08002be10318}\<instance>\GlobalSettings\Device0]
3. Make sure the <instance> is IntcDMic.sys



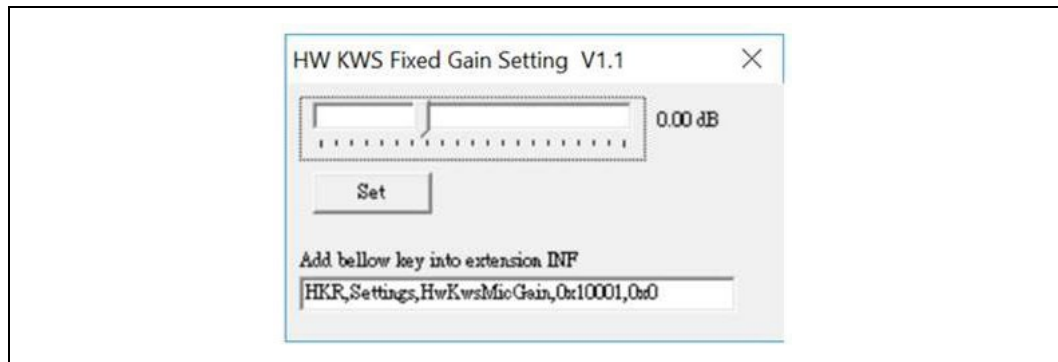
4. Set the Gain with DWORD type to registry



- Re-test SPET and make sure MIC sensitivity setting take effect
- Integrate the registry setting in audio installation package at production stage.

6.5 Calibrate Gain for DMIC-to-Codec Design

At tuning stage, use RTK tool - SetHWKWSMicGain to set the gain



At production stage, write gain into RTK defined registry.

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7 Intel® SST Driver from Inbox Driver on Audio DSP Disabled System

The newest proposal between Microsoft* and Intel assures and enables customers to keep UAA compliant hardware IDs while still supporting the Intel® SST driver stack.

Systems that use the HD-A interface are recognized to be UAA compliant. Refer below for the proposals:

- **Microsoft* Inbox HD-A Bus Driver**
 - Match on PCI\CC_0403
 - Child PnP IDs are "HDAUDIO\..."
- **Intel HD-A Bus Driver**
 - Match on PCI\VEN_8086&DEV_1324&CC_040301
 - Match on PCI\VEN_8086&DEV_1234&CC_040100
 - Child PnP IDs are "INTELAUDIO\..."

As such:

Class	Subclass	Programming Interface	Drivers Supported
04	03	00	Microsoft* Bus Driver ¹ (Windows* 7+)
04	03	80	Microsoft* Bus Driver ¹ (Windows* 7+) Intel® SST Bus Driver (Windows* 8+)
04	01	00	Intel® SST Bus Driver (Windows* 8+)

Note: Platform configuration must be UAA compliant (example, DMIC must attach to codec, I2S) for Microsoft* bus driver support.

- **Row1 with class code 040300:** Legacy systems that support the Microsoft* Inbox Bus driver that is UAA compliant. This value is required to be used on the non-SST systems with DMIC attached to the HD-A Codec.
- **Row2 with class code 040380:** This value is required to be used on SST enabled systems with DMIC attached to HD-A Codec.
- **Row3 with class code 040100:** This is for systems where the DMIC is attached to the PCH via the PDM interface thus deeming it to be a non UAA compliant system.

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